

FORMATION AND STABILITY OF RADIATION PRODUCTS IN EUROPA'S ICY SHELL M. H.

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Introduction: Spectra of Europa reveal a surface dominated by water-ice [1] along with hydrated materials [2,3] and minor amounts of SO₂ [4,5], CO₂ [6], and H₂O₂ [7]. Jovian magnetospheric ions (protons, sulfur, and oxygen) and electrons produce significant chemical modifications of the surface on time scales of a few years at micrometer depths [8]. Our laboratory studies examine the formation and stability of radiation products in H₂O-rich ices relevant to Europa. Infrared (IR) spectra of ices before and after irradiation reveal the radiation destruction of molecules and the formation of products at 86 – 132 K. In addition, spectra of ices during warming track thermal evolution due to chemical changes and sublimation processes.

IR-identified radiation products in 86 - 132 K irradiated H₂O + SO₂ ices are the bisulfate ion, HSO₄⁻, sulfate ion, SO₄²⁻, and the hydronium ion, H₃O⁺. Warming results in the formation of a residual spectrum similar to liquid sulfuric acid, H₂SO₄, for H₂O:SO₂ ratios of 3:1, whereas hydrated sulfuric acid, H₂SO₄ · 4 H₂O, forms for ratios of 30:1. Radiation products identified for irradiated H₂O + H₂S ices at 86 K are H₂S₂ and SO₂. When irradiated at 110 and 132 K, ices with H₂O:H₂S ratios of either 3:1 or 30:1 show the formation of H₂SO₄ · 4 H₂O on warming to 175 K. We have also examined the radiation stability of H₂SO₄.

Addition of CO₂ to H₂O + SO₂ ices results in the formation of CO₃ at 2046 cm⁻¹ (4.89 μm). This is the strongest band from a carbon-containing product in the mid-IR spectral region, and it is also seen when either pure CO₂ or H₂O + CO₂ ice is irradiated. Experiments with CH₄ added to H₂O + SO₂ + CO₂ ices

addressed the question of methane's use as a marker of methanogens in an irradiated ice environment.

New results on the near-IR spectrum of pure H₂O₂ will be included in this presentation. Interpretations of near-IR water bands, with H₂O₂ present, will be discussed. Irradiations of H₂O₂ and H₂O + H₂O₂ mixtures, to examine the possibility of O₂ and O₃ formation [9], are currently under investigation and new results will be discussed.

These laboratory studies provide fundamental information on likely processes affecting the outer layer of Europa's icy shell. This layer has the coldest, most heavily bombarded material in which radiation chemical markers of H₂O₂ and O₂ have already been detected. Through downward mixing, gardening, and subduction, these surface species may become available for subsurface activity.

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